PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-001307
(43)Date of publication of application : 07.01.2003

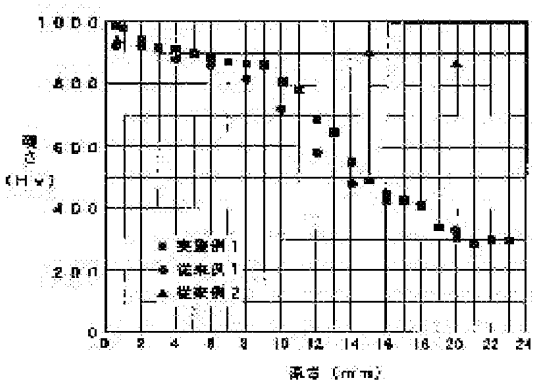
(51)Int.Cl. B21B 27/00
C22C 38/00
C22C 38/24

(21)Application number : 2001-185146
(22)Date of filing : 19.06.2001

(71)Applicant : NIPPON KOSHUHA STEEL CO LTD
(72)Inventor : YANO MASAHIKO

(54) ROLL

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a roll at a low cost which is tough in the inner portion and hard in the surface portion required as a roll having a good wear resistance and dent resistance.
SOLUTION: A roll is made from an alloy containing C 0.8-1.2 mass%, Si 0.3-0.5 mass%, Mn 0.4-0.6 mass%, Cr 2.5-4.0 mass%, Mo 0.3-0.5 mass%, V 0.3 mass% max., balance FE plus inevitable impurities. The Vickers hardness of the surface portion of 4 to 8-mm depth from the surface to the center portion is 900 Hv min. and that of the deeper portion than this surface portion is less than 900 Hv.



* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1]A reduction roll characterized by the following.
C: 0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn:0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass %.
The remainder is fabricated from an alloy which consists of Fe and inevitable impurities, Vickers hardness number [in / towards the central part from the surface / a layer part in 4 thru/or 8-mm Fukashi] is 900 or more HV, and Vickers hardness number of an inside is less than 900 HV from this layer part.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention]This invention relates to the reduction roll which was used suitably for a work roll and in which abrasion resistance and dent-proof nature were excellent especially about the reduction roll used for the rolling mill which rolls steel, a nonferrous material, etc.
[0002]
[Description of the Prior Art]Although the work roll for cold rolling of a steel plate needs for the surface to be smooth among reduction rolls, When dent-proof nature is low, by permeation of the foreign matter to this dent, etc., the surface of a roll may change while in use, modification may be made to remain for a product by that deformed portion, and the debasement of a product may be caused. If abrasion resistance is low, while in use, wear occurs at an early stage, and the cycle of regrinding will become short and will cause decline in rolling efficiency.
[0003]To abrasion resistance, add V, and minuteness making of a crystal grain is attained, and it is effective to make VC carbide form. As such art, the wear-resistant cold rolling roll with which a shell diameter is used as a work roll or an intermediate roll not less than 250-mm of a major diameter, etc. is conventionally indicated by JP,61-21300,B (patent No. 134413) (conventional example 1). In order that the reduction roll of the conventional example 1 may suppress the hardness in a shank and the trunk central part with Shore hardness to below HS50 (it is 360HV at Vickers hardness number) and may give toughness, it is applied to the major-diameter roll of not less than 250 mm of shell diameters. And only a layer part makes Shore hardness the high hardness more than HS90 (it is 820HV at Vickers hardness number), and is improving abrasion resistance.
[0004]Without spoiling abrasion resistance, thermal shock resistance, etc. which are demanded in a forged steel roll to JP,57-39160,A, A forged steel roll whose high hardness-ized depth, especially Shore hardness have the super-high case depth from which the high hardening layer more than HS90 (it is 820HV at Vickers hardness number) serves as a range from a roll surface to a depth of 35 thru/or 45 mm, and a manufacturing method for the same are indicated (conventional example 2). Since nickel is added in this conventional example 2, hardness penetration can be made deep and it can have hardness high to the central part of a roll.
[0005]
[Problem(s) to be Solved by the Invention]However, in the art of the conventional example 1, about V, if 2.0 mass % addition of is done and the addition of V is increased [0.8 thru/or] in this way, a manufacturing cost will become high, and it is not general-purpose. Unless the addition of C and Cr is also less than an appropriate amount, it becomes insufficient forming of the Cr carbide which has on hardness and abrasion resistance, and hardness and abrasion resistance required as a roll material cannot be obtained.
[0006]In order to obtain high hardness from the use life of a roll like [what is necessary is just to be the surface hardness which can maintain abrasion resistance, and] the conventional example 2 after regrinding of the roll surface which carries out number-of-times operation of specific, when high hardness more than needed is used to the roll central part, there is a problem of reducing the toughness of the roll central part.
[0007]This invention was made in view of this problem, and is ****. The purpose is excellent in toughness and a layer part is providing the reduction roll which has high hardness required as a reduction roll, and abrasion resistance and dent-proof nature are excellent in, and can be obtained by low cost.

[0008]
[Means for Solving the Problem]A reduction roll concerning this invention C:0.8 thru/or 1.2 mass %, Si:0.3

thru/or 0.5 mass %, Mn:0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, The remainder is fabricated from an alloy which consists of Fe and inevitable impurities, towards the central part from the surface, Vickers hardness number in a layer part in 4 thru/or 8-mm Fukashi is 900 or more HV, and an inside is characterized by Vickers hardness number being less than 900 HV rather than this layer part. When Vickers hardness number 900HV is converted into Shore hardness, it is HS95.

[0009]Since hardness [in / towards the central part from the surface / a layer part in 4 thru/or 8-mm Fukashi] is 900 or more HV and an inside is less than 900 HV in Vickers hardness number from this layer part in this invention, Abrasion resistance and dent-proof nature are excellent, and a reduction roll which stops hardness and has required toughness from a layer part is obtained in an inside of a roll.

[0010]

[Embodiment of the Invention]Hereafter, the reduction roll concerning the example of this invention is explained in detail. The reduction roll of this example is used, for example for the work roll of a steel plate cold rolling roll, etc. This reduction roll C:0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn: 0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, and the remainder is obtained by fabricating the alloy which consists of Fe and inevitable impurities. The inside is 900 or more HV in hardness [in / towards the central part from the surface / in this reduction roll / the layer part in 4 thru/or 8-mm Fukashi] in Vickers hardness number, and is less than 900 HV in hardness in Vickers hardness number from this layer part.

[0011]Next, the manufacturing method of the reduction roll concerning this example is explained. First, C:0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn:0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, Hot forging of the alloy which consists of Fe and inevitable impurities is cast and carried out, and it forges in predetermined shape, and further, the remainder performs balling-up annealing and carries out rough machining of the surface after that. Then, surface hardening is carried out with hardening annealing, induction hardening, etc. Thereby, the hard hardening layer of 900 or more HV is formed for the Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi towards the central part from a roll surface. In surface hardening, although it becomes high hardness in a layer part, hardening depth does not become deep too much, and in the central part, Vickers hardness number is less than 900 HV, and the inside can stop hardness, and can acquire required toughness rather than this layer part. This case hardening can be hardened on the conditions shown, for example in the following table 2.

[0012]Hereafter, the reason for a numerical limitation of the reduction roll concerning this invention is explained.

[0013]Shortage or deposit carbide runs short of the amounts of C dissolution as the content of C:1.0 thru/or 1.2 mass %C is less than 1.0 mass %, hardness runs short at the time of surface hardening, and the purpose of this invention cannot be attained. On the other hand, if the content of C exceeds 1.2 mass %, retained austenite will increase, and it will be stabilized and hardness will become low. Mechanical properties, especially toughness fall remarkably. Therefore, content of C is taken as 1.0 thru/or 1.2 mass %.

[0014]Si: 0.3 thru/or 0.5 mass %Si dissolve mainly to a base material, and has the operation which raises tempering resistance. Since it is used as a deoxidizer, it exists unescapable. However, the above-mentioned operation is not obtained as the content of Si is less than 0.3 mass %, but on the other hand, if the content of Si exceeds 0.5 mass %, the lift of the molten steel in a solid-liquid coexisting phase will become large, and will produce a segregation especially in the central part or an inside gradually. Therefore, content of Si is taken as 0.3 thru/or 0.5 mass %.

[0015]Mn: 0.4 thru/or 0.6 mass %Mn act as a deoxidizer like Si, and it has hardening remarkable in improvement in hardenability. However, the above-mentioned effect is not acquired as the content of Mn is less than 0.4 mass %, but on the other hand, if the content of Mn exceeds 0.6 mass %, crack resistance will be worsened. Therefore, content of Mn is taken as 0.4 thru/or 0.6 mass %.

[0016]Cr: 2.5 thru/or 4.0 mass %Cr are carbide formation elements, and if it heats induction hardening etc. to an austenite region, it will dissolve easily. Carbide has the effect of improving abrasion resistance. However, the carbide of sufficient quantity for obtaining abrasion resistance required as a roll material as the content of Cr is less than 2.5 mass % is not obtained, but on the other hand, if the content of Cr exceeds 4.0 mass %, crack resistance will deteriorate. Therefore, content of Cr is taken as 2.5 thru/or 4.0 mass %.

[0017]Mo: Like Cr, 0.3 thru/or 0.5 mass %Mo are powerful carbide formation elements, and has the effect of improving hardness, abrasion resistance, and dent-proof nature. However, hardness required as a roll material,

abrasion resistance, and dent-proof nature are not obtained as the content of Mo is less than 0.3 mass %, but on the other hand, if the content of Mo exceeds 0.5 mass %, heat treatment will become difficult. Therefore, content of Mo is taken as 0.3 thru/or 0.5 mass %.
[0018]V: Below 0.3 mass % V carries out minuteness making of the crystal grain, and it forms VC carbide and has the effect of improving abrasion resistance and dent-proof nature. However, a manufacturing cost will become high if the addition of V is increased. Therefore, it is appropriate for the addition of V that below 0.3 mass % carries out.
[0019]The Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi towards the central part from a roll surface 900 or more HV, Rather than this layer part, if an inside is 900 or more HV, the Vickers hardness number in the layer part whose depth (henceforth depth) in which Vickers hardness number goes to the central part from less than 900 HV surface is 4-8 mm, Dent-proof nature is excellent and the surface of a roll can be prevented from changing while in use by permeation of a foreign matter, etc. Abrasion resistance is excellent, wear in use is reduced, the cycle of regrinding becomes long, and rolling efficiency can be improved. However, internal toughness deteriorates that the Vickers hardness number in a part with the depth of greater than 8 mm from the surface is 900 or more HV. If the depth of the layer part whose Vickers hardness number is 900 or more HV is shallower than 4 mm, abrasion resistance required as a roll material and dent-proof nature will not be obtained. Therefore, Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi is set to 900 or more HV towards the central part from a roll surface, and an inside sets Vickers hardness number to less than 900 HV rather than this layer part.
[0020]
[Example]The example which actually manufactured the reduction roll of this invention is hereafter compared with the conventional example from which it separates from this invention range, and the effect of this invention is explained.
[0021]The roll which has the chemical composition of Examples 1-3 of this invention, the above-mentioned conventional example 1, and the conventional example 2 was manufactured as a cold rolling roll. First, the ingot which has the chemical composition shown in the following table 1 was cast, and hot forging, balling-up annealing, and rough machining were performed. Then, hardening temper of the main part was performed and case hardening was carried out on the conditions shown in the following table 2. It is shown that the slash shown in the column of nickel of the following table 1 contains nickel as inevitable impurities.
[0022]Vickers hardness number was measured by Fukashi up to 23 mm towards the central part from the surface of the obtained roll. This result is shown in the following table 3 and drawing 1.
[0023]The Charpy impact test was done from the surface of the roll to the part 30 thru/or 50 mm deep towards the central part. The result is shown in drawing 2. The toughness inside each roll was evaluated from the value of the Charpy impact value measured by this Charpy impact test. Evaluation of toughness made O that whose impact resistance value is more than 50 J/cm^2, the impact resistance value exceeded 20 J/cm^2, and it made ** what is less than 50 J/cm^2, and made x that whose impact resistance value is below 20 J/cm^2.

[0024]In order to evaluate abrasion resistance, an Ogoe style wear test was done. This result is shown in drawing 3. The test condition set the mating material to SUJ2 (Rockwell hardness: HRC45 (about 450 HV)), and load was 6.3 kg and it set wear distance to 400 m. setting wear-resistant evaluation to each friction speed -- a ratio -- it was considered as O, **, and x from what has small abrasion loss.
[0025]The cost which production of the obtained roll takes, the maximum hardness of a roll, the hardness penetration of a roll, the toughness of a roll, and the above-mentioned wear-resistant evaluation are shown in the following table 4. The content of V and nickel estimated, V content made O that by which nickel is not added below as for 0.30 mass %, and the cost of the roll made x that by which V content exceeds 0.30 mass %, or nickel is added. The maximum hardness of the hardness which the maximum hardness of the roll measured made ** O and the thing of less than 940 HV for the thing of 940 or more HV. Hardness [in / in the hardness penetration of a roll / the layer part from a roll surface to 4 thru/or 8 mm] made the thing of 900 or more HV O, and the hardness in the layer part from a roll surface to 4 thru/or 8 mm made the thing of less than 900 HV x.
[0026]
[Table 1]

試料No.	C	Si	Mn	Cr	Mo	V	Ni
実施例1	1.13	0.35	0.50	2.87	0.41	0.22	
実施例2	1.03	0.33	0.52	3.36	0.43	0.21	
実施例3	1.18	0.34	0.50	3.01	0.38	0.21	
従来例1	1.25	0.32	0.34	2.96	0.26	1.02	
従来例2	0.88	0.64	0.50	3.34	0.35	0.07	0.60

[0027]
[Table 2]

発信機	サイリスタ　１ｋＨｚ
焼入れ	予熱１回、その後、９５０℃に保持
送り	予熱：３．５ｍ／秒、焼入れ：２．０ｍ／秒
出力	７０ｋＷ
冷却水	水

[0028]
[Table 3]

測定距離	実施例１	実施例２	実施例３	従来例１	従来例２
０．５	９８９	９８３	９９７	９３０	９４０
１	９８５	９８２	９９６	－	－
２	９４０	９３７	９６２	９２０	－
３	９２８	９２４	９５３	－	－
４	９２１	９０２	９４３	８８０	－
５	９０５	９２０	９３８	－	－
６	８８５	８８０	９１４	８６０	－
７	８７４	８６４	８９６	－	－
８	８７１	８６１	８８２	８１５	－
９	８６８	８５７	８８６	－	－
１０	８１２	８０１	８２９	７２０	－
１１	７８１	７８３	８０３	－	－
１２	６８７	６８４	７２１	５８５	－
１３	６４７	６３９	６７２	－	－
１４	５５０	５４７	５７３	４８５	－
１５	４９１	４８７	５０６	－	９００
１６	４５０	４７５	４６１	４２５	－
１７	４３２	４３０	４４０	－	－
１８	４１１	４０９	３８６	４１０	－
１９	３４８	３４２	３４８	－	－
２０	３０１	２８９	３３２	３３０	８７０
２１	２９１	２８７	３０１	－	－
２２	２９８	２８５	２９５	３０２	－
２３	３００	２８２	３０２	－	－

[0029]
[Table 4]

	コスト	最高硬さ	焼入深度	靭性	耐摩耗性
実施例１	○	○	○	○	○
実施例２	○	○	○	○	○
実施例３	○	○	○	○	○
従来例１	×	△	×	○	△
従来例２	×	○	×	×	×

[0030]As shown in Table 3, Vickers hardness number [in / towards the central part from a roll surface / in Example 1 and Example 2 / the layer part in 5-mm Fukashi] was 900 or more HV. Vickers hardness number [in / towards the central part from a roll surface / in Example 3 / the layer part in about 7-mm Fukashi] was 900 or more HV. Although Vickers hardness number [in / towards the central part from a roll surface / in the conventional example 1 / the layer part in 2-mm Fukashi] was 900 or more HV, in a 4-mm position, Vickers hardness number was 880HV. The Vickers hardness number of the conventional example 2 was 900 or more HV from the roll surface to a 15-mm position exceeding a depth of 8 mm towards the central part.

[0031]Drawing 1 is graph charts taking Vickers hardness (HV) along a vertical axis, and taking the depth (mm) from a roll surface along a horizontal axis and in which showing the hardness distribution of the reduction roll of Example 1 and the conventional examples 1 and 2. As shown in drawing 1, hardness [in / towards the central part from the surface / in Example 1 / the layer part in 4 thru/or 8-mm Fukashi] is high as compared with the conventional example 1.

[0032]Drawing 2 is graph charts taking a Charpy impact value (J/cm^2) along a vertical axis and in which showing the toughness of Example 1 in a 30 thru/or 50-mm part, and the conventional examples 1 and 2 towards the central part from a roll surface. As shown in Table 4 and drawing 1, also in the part (inside) where the depth which goes to the central part from the surface is deeper than Example 1, hardness is high, but the conventional example 1. As shown in drawing 2, the value of a Charpy impact value [in / towards the central part / a 30 thru/or 50-mm part] is [in / to being a 55 J/cm^2 grade / the conventional example 2] a 15 J/cm^2 grade in Example 1 from the surface.

It turns out that the toughness near the roll central part of Example 1 excels the conventional example 2 in whether you are Haruka.

In Example 1, 330HV and the conventional example 2 were [865HV and the conventional example 1 of the Vickers hardness in the part which measured the Charpy impact value] 350HV.

[0033]drawing 3 -- a vertical axis -- a ratio -- they are graph charts taking friction speed (m/second) along a horizontal axis, and showing the abrasion resistance of Example 1 and the conventional examples 1 and 2 on it for abrasion loss ($1.02x10^{-11}m^3/N-m$). scratching Example 1 and comparing it with the conventional examples 1 and 2 irrespective of a wear rate in an abrasion region, as shown in drawing 3 -- a ratio -- there is little abrasion loss and it turns out that abrasion resistance is excellent.

[0034]When Example 1 was compared with the conventional example 1, the difference arose in maximum hardness and there was no difference in the toughness near the roll surface. To the conventional example 1, Example 1 adds a proper quantity of Mo of a carbide formation element, and is raising the abrasion resistance after high-frequency induction hardening. Since the conventional example 1 has added V so much, it becomes disadvantageous by a cost aspect.

[0035]Although a difference was not looked at by maximum hardness when Example 1 was compared with the conventional example 2, toughness [/ near the surface of Example 1] was superior to the conventional example 2. To the conventional example 2, Example 1 adds V, forms VC carbide, and is raising abrasion resistance. On the other hand, the conventional example 2 did not add V, but added nickel instead, and has secured the hardenability of a raw material. For this reason, although a difference arises from the surface to ****** and a difference is not observed in the maximum hardness in the surface, a difference arises in the toughness near the surface.

[0036]

[Effect of the Invention]In this invention, as explained in full detail above, since the chemical entity was specified appropriately, it is obtained by low cost and stop the hardness of the central part of a roll, and. In order to set Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi to 900 or more HV towards the central part from a roll surface and to set an inside to less than 900 HV by Vickers hardness number rather than this layer part, The central part is excellent in toughness, and the layer part can obtain the reduction roll excellent in abrasion resistance and dent-proof nature, and, thereby, can lengthen the use life of a reduction roll.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention]This invention relates to the reduction roll which was used suitably for a work roll and in which abrasion resistance and dent-proof nature were excellent especially about the reduction roll used for the rolling mill which rolls steel, a nonferrous material, etc.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art]Although the work roll for cold rolling of a steel plate needs for the surface to be smooth among reduction rolls, When dent-proof nature is low, by permeation of the foreign matter to this dent, etc., the surface of a roll may change while in use, modification may be made to remain for a product by that deformed portion, and the debasement of a product may be caused. If abrasion resistance is low, while in use, wear occurs at an early stage, and the cycle of regrinding will become short and will cause decline in rolling efficiency.
[0003]To abrasion resistance, add V, and minuteness making of a crystal grain is attained, and it is effective to make VC carbide form. As such art, the wear-resistant cold rolling roll with which a shell diameter is used as a work roll or an intermediate roll not less than 250-mm of a major diameter, etc. is conventionally indicated by JP,61-21300,B (patent No. 134413) (conventional example 1). In order that the reduction roll of the conventional example 1 may suppress the hardness in a shank and the trunk central part with Shore hardness to below HS50 (it is 360HV at Vickers hardness number) and may give toughness, it is applied to the major-diameter roll of not less than 250 mm of shell diameters. And only a layer part makes Shore hardness the high hardness more than HS90 (it is 820HV at Vickers hardness number), and is improving abrasion resistance.
[0004]Without spoiling abrasion resistance, thermal shock resistance, etc. which are demanded in a forged steel roll to JP,57-39160,A, A forged steel roll whose high hardness-ized depth, especially Shore hardness have the super-high case depth from which the high hardening layer more than HS90 (it is 820HV at Vickers hardness number) serves as a range from a roll surface to a depth of 35 thru/or 45 mm, and a manufacturing method for the same are indicated (conventional example 2). Since nickel is added in this conventional example 2, hardness penetration can be made deep and it can have hardness high to the central part of a roll.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]In this invention, as explained in full detail above, since the chemical entity was specified appropriately, it is obtained by low cost and stop the hardness of the central part of a roll, and. In order to set Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi to 900 or more HV towards the central part from a roll surface and to set an inside to less than 900 HV by Vickers hardness number rather than this layer part, The central part is excellent in toughness, and the layer part can obtain the reduction roll excellent in abrasion resistance and dent-proof nature, and, thereby, can lengthen the use life of a reduction roll.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]However, in the art of the conventional example 1, about V, if 2.0 mass % addition of is done and the addition of V is increased [0.8 thru/or] in this way, a manufacturing cost will become high, and it is not general-purpose. Unless the addition of C and Cr is also less than an appropriate amount, it becomes insufficient forming of the Cr carbide which has on hardness and abrasion resistance, and hardness and abrasion resistance required as a roll material cannot be obtained.
[0006]In order to obtain high hardness from the use life of a roll like [what is necessary is just to be the surface hardness which can maintain abrasion resistance, and] the conventional example 2 after regrinding of the roll surface which carries out number-of-times operation of specific, when high hardness more than needed is used to the roll central part, there is a problem of reducing the toughness of the roll central part.
[0007]This invention was made in view of this problem, and is ****. The purpose is excellent in toughness and a layer part is providing the reduction roll which has high hardness required as a reduction roll, and abrasion resistance and dent-proof nature are excellent in, and can be obtained by low cost.

[Translation done.]

MEANS

[Means for Solving the Problem]A reduction roll concerning this invention C:0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn:0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, The remainder is fabricated from an alloy which consists of Fe and inevitable impurities, towards the central part from the surface, Vickers hardness number in a layer part in 4 thru/or 8-mm Fukashi is 900 or more HV, and an inside is characterized by Vickers hardness number being less than 900 HV rather than this layer part. When Vickers hardness number 900HV is converted into Shore hardness, it is HS95.
[0009]Since hardness [in / towards the central part from the surface / a layer part in 4 thru/or 8-mm Fukashi] is 900 or more HV and an inside is less than 900 HV in Vickers hardness number from this layer part in this invention, Abrasion resistance and dent-proof nature are excellent, and a reduction roll which stops hardness and has required toughness from a layer part is obtained in an inside of a roll.
[0010]
[Embodiment of the Invention]Hereafter, the reduction roll concerning the example of this invention is explained in detail. The reduction roll of this example is used, for example for the work roll of a steel plate cold rolling roll, etc. This reduction roll C:0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn: 0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, and the remainder is obtained by fabricating the alloy which consists of Fe and inevitable impurities. The inside is 900 or more HV in hardness [in / towards the central part from the surface / in this reduction roll / the layer part in 4 thru/or 8-mm Fukashi] in Vickers hardness number, and is less than 900 HV in hardness in Vickers hardness number from this layer part.
[0011]Next, the manufacturing method of the reduction roll concerning this example is explained. First, C:0.8 thru/or 1.2 mass %, Si:0.3 thru/or 0.5 mass %, Mn:0.4 thru/or 0.6 mass %, Cr:2.5 thru/or 4.0 mass %, Mo:0.3 thru/or 0.5 mass %, and below V:0.3 mass % are contained, Hot forging of the alloy which consists of Fe and inevitable impurities is cast and carried out, and it forges in predetermined shape, and further, the remainder performs balling-up annealing and carries out rough machining of the surface after that. Then, surface hardening is carried out with hardening annealing, induction hardening, etc. Thereby, the hard hardening layer of 900 or more HV is formed for the Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi towards the central part from a roll surface. In surface hardening, although it becomes high hardness in a layer part, hardening depth does not become deep too much, and in the central part, Vickers hardness number is less than 900 HV, and the inside can stop hardness, and can acquire required toughness rather than this layer part. This case hardening can be hardened on the conditions shown, for example in the following table 2.
[0012]Hereafter, the reason for a numerical limitation of the reduction roll concerning this invention is explained.
[0013]Shortage or deposit carbide runs short of the amounts of C dissolution as the content of C:1.0 thru/or 1.2 mass %C is less than 1.0 mass %, hardness runs short at the time of surface hardening, and the purpose of this invention cannot be attained. On the other hand, if the content of C exceeds 1.2 mass %, retained austenite will increase, and it will be stabilized and hardness will become low. Mechanical properties, especially toughness fall remarkably. Therefore, content of C is taken as 1.0 thru/or 1.2 mass %.
[0014]Si: 0.3 thru/or 0.5 mass %Si dissolve mainly to a base material, and has the operation which raises tempering resistance. Since it is used as a deoxidizer, it exists unescapable. However, the above-mentioned operation is not obtained as the content of Si is less than 0.3 mass %, but on the other hand, if the content of Si exceeds 0.5 mass %, the lift of the molten steel in a solid-liquid coexisting phase will become large, and will

produce a segregation especially in the central part or an inside gradually. Therefore, content of Si is taken as 0.3 thru/or 0.5 mass %.

[0015]Mn: 0.4 thru/or 0.6 mass %Mn act as a deoxidizer like Si, and it has hardening remarkable in improvement in hardenability. However, the above-mentioned effect is not acquired as the content of Mn is less than 0.4 mass %, but on the other hand, if the content of Mn exceeds 0.6 mass %, crack resistance will be worsened. Therefore, content of Mn is taken as 0.4 thru/or 0.6 mass %.

[0016]Cr: 2.5 thru/or 4.0 mass %Cr are carbide formation elements, and if it heats induction hardening etc. to an austenite region, it will dissolve easily. Carbide has the effect of improving abrasion resistance. However, the carbide of sufficient quantity for obtaining abrasion resistance required as a roll material as the content of Cr is less than 2.5 mass % is not obtained, but on the other hand, if the content of Cr exceeds 4.0 mass %, crack resistance will deteriorate. Therefore, content of Cr is taken as 2.5 thru/or 4.0 mass %.

[0017]Mo: Like Cr, 0.3 thru/or 0.5 mass %Mo are powerful carbide formation elements, and has the effect of improving hardness, abrasion resistance, and dent-proof nature. However, hardness required as a roll material, abrasion resistance, and dent-proof nature are not obtained as the content of Mo is less than 0.3 mass %, but on the other hand, if the content of Mo exceeds 0.5 mass %, heat treatment will become difficult. Therefore, content of Mo is taken as 0.3 thru/or 0.5 mass %.

[0018]V: Below 0.3 mass % V carries out minuteness making of the crystal grain, and it forms VC carbide and has the effect of improving abrasion resistance and dent-proof nature. However, a manufacturing cost will become high if the addition of V is increased. Therefore, it is appropriate for the addition of V that below 0.3 mass % carries out.

[0019]The Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi towards the central part from a roll surface 900 or more HV, Rather than this layer part, if an inside is 900 or more HV, the Vickers hardness number in the layer part whose depth (henceforth depth) in which Vickers hardness number goes to the central part from less than 900 HV surface is 4-8 mm, Dent-proof nature is excellent and the surface of a roll can be prevented from changing while in use by permeation of a foreign matter, etc. Abrasion resistance is excellent, wear in use is reduced, the cycle of regrinding becomes long, and rolling efficiency can be improved. However, internal toughness deteriorates that the Vickers hardness number in a part with the depth of greater than 8 mm from the surface is 900 or more HV. If the depth of the layer part whose Vickers hardness number is 900 or more HV is shallower than 4 mm, abrasion resistance required as a roll material and dent-proof nature will not be obtained. Therefore, Vickers hardness number in the layer part in 4 thru/or 8-mm Fukashi is set to 900 or more HV towards the central part from a roll surface, and an inside sets Vickers hardness number to less than 900 HV rather than this layer part.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

EXAMPLE

[Example]The example which actually manufactured the reduction roll of this invention is hereafter compared with the conventional example from which it separates from this invention range, and the effect of this invention is explained.
[0021]The roll which has the chemical composition of Examples 1-3 of this invention, the above-mentioned conventional example 1, and the conventional example 2 was manufactured as a cold rolling roll. First, the ingot which has the chemical composition shown in the following table 1 was cast, and hot forging, balling-up annealing, and rough machining were performed. Then, hardening temper of the main part was performed and case hardening was carried out on the conditions shown in the following table 2. It is shown that the slash shown in the column of nickel of the following table 1 contains nickel as inevitable impurities.
[0022]Vickers hardness number was measured by Fukashi up to 23 mm towards the central part from the surface of the obtained roll. This result is shown in the following table 3 and drawing 1.
[0023]The Charpy impact test was done from the surface of the roll to the part 30 thru/or 50 mm deep towards the central part. The result is shown in drawing 2. The toughness inside each roll was evaluated from the value of the Charpy impact value measured by this Charpy impact test. Evaluation of toughness made O that whose impact resistance value is more than 50 J/cm^2, the impact resistance value exceeded 20 J/cm^2, and it made ** what is less than 50 J/cm^2, and made x that whose impact resistance value is below 20 J/cm^2.

[0024]In order to evaluate abrasion resistance, an Ogoe style wear test was done. This result is shown in drawing 3. The test condition set the mating material to SUJ2 (Rockwell hardness: HRC45 (about 450 HV)), and load was 6.3 kg and it set wear distance to 400 m. setting wear-resistant evaluation to each friction speed -- a ratio -- it was considered as O, **, and x from what has small abrasion loss.
[0025]The cost which production of the obtained roll takes, the maximum hardness of a roll, the hardness penetration of a roll, the toughness of a roll, and the above-mentioned wear-resistant evaluation are shown in the following table 4. The content of V and nickel estimated, V content made O that by which nickel is not added below as for 0.30 mass %, and the cost of the roll made x that by which V content exceeds 0.30 mass %, or nickel is added. The maximum hardness of the hardness which the maximum hardness of the roll measured made ** O and the thing of less than 940 HV for the thing of 940 or more HV. Hardness [in / in the hardness penetration of a roll / the layer part from a roll surface to 4 thru/or 8 mm] made the thing of 900 or more HV O, and the hardness in the layer part from a roll surface to 4 thru/or 8 mm made the thing of less than 900 HV x.
[0026]
[Table 1]

試料No.	C	Si	Mn	Cr	Mo	V	Ni
実施例1	1.13	0.35	0.50	2.87	0.41	0.22	
実施例2	1.03	0.33	0.52	3.36	0.43	0.21	
実施例3	1.18	0.34	0.50	3.01	0.38	0.21	
従来例1	1.25	0.32	0.34	2.96	0.26	1.02	
従来例2	0.88	0.64	0.50	3.34	0.35	0.07	0.60

[0027]
[Table 2]

発信機	サイリスタ　１ｋＨｚ
焼入れ	予熱１回、その後、９５０℃に保持
送り	予熱：３．５ｍ／秒、焼入れ：２．０ｍ／秒
出力	７０ｋＷ
冷却水	水

[0028]
[Table 3]

測定距離	実施例１	実施例２	実施例３	従来例１	従来例２
０．５	９８９	９８３	９９７	９３０	９４０
１	９８５	９８２	９９６	－	－
２	９４０	９３７	９６２	９２０	－
３	９２８	９２４	９５３	－	－
４	９２１	９０２	９４３	８８０	－
５	９０５	９２０	９３８	－	－
６	８８５	８８０	９１４	８６０	－
７	８７４	８６４	８９６	－	－
８	８７１	８６１	８８２	８１５	－
９	８６８	８５７	８８６	－	－
１０	８１２	８０１	８２９	７２０	－
１１	７８１	７８３	８０３	－	－
１２	６８７	６８４	７２１	５８５	－
１３	６４７	６３９	６７２	－	－
１４	５５０	５４７	５７３	４８５	－
１５	４９１	４８７	５０６	－	９００
１６	４５０	４７５	４６１	４２５	－
１７	４３２	４３０	４４０	－	－
１８	４１１	４０９	３８６	４１０	－
１９	３４８	３４２	３４８	－	－
２０	３０１	２８９	３３２	３３０	８７０
２１	２９１	２８７	３０１	－	－
２２	２９８	２８５	２９５	３０２	－
２３	３００	２８２	３０２	－	－

[0029]
[Table 4]

	コスト	最高硬さ	焼入深度	靭性	耐摩耗性
実施例１	○	○	○	○	○
実施例２	○	○	○	○	○
実施例３	○	○	○	○	○
従来例１	×	△	×	○	△
従来例２	×	○	×	×	×

[0030]As shown in Table 3, Vickers hardness number [in / towards the central part from a roll surface / in Example 1 and Example 2 / the layer part in 5-mm Fukashi] was 900 or more HV. Vickers hardness number [in / towards the central part from a roll surface / in Example 3 / the layer part in about 7-mm Fukashi] was 900 or more HV. Although Vickers hardness number [in / towards the central part from a roll surface / in the conventional example 1 / the layer part in 2-mm Fukashi] was 900 or more HV, in a 4-mm position, Vickers hardness number was 880HV. The Vickers hardness number of the conventional example 2 was 900 or more HV from the roll surface to a 15-mm position exceeding a depth of 8 mm towards the central part.
[0031]Drawing 1 is graph charts taking Vickers hardness (HV) along a vertical axis, and taking the depth (mm) from a roll surface along a horizontal axis and in which showing the hardness distribution of the reduction roll of Example 1 and the conventional examples 1 and 2. As shown in drawing 1, hardness [in / towards the central part from the surface / in Example 1 / the layer part in 4 thru/or 8-mm Fukashi] is high as compared with the conventional example 1.
[0032]Drawing 2 is graph charts taking a Charpy impact value (J/cm^2) along a vertical axis and in which showing the toughness of Example 1 in a 30 thru/or 50-mm part, and the conventional examples 1 and 2 towards the central part from a roll surface. As shown in Table 4 and drawing 1, also in the part (inside) where the depth which goes to the central part from the surface is deeper than Example 1, hardness is high, but the conventional example 1. As shown in drawing 2, the value of a Charpy impact value [in / towards the central part / a 30 thru/or 50-mm part] is [in / to being a 55 J/cm^2 grade / the conventional example 2] a 15 J/cm^2 grade in Example 1 from the surface.
It turns out that the toughness near the roll central part of Example 1 excels the conventional example 2 in whether you are Haruka.
In Example 1, 330HV and the conventional example 2 were [865HV and the conventional example 1 of the Vickers hardness in the part which measured the Charpy impact value] 350HV.
[0033]drawing 3 -- a vertical axis -- a ratio -- they are graph charts taking friction speed (m/second) along a horizontal axis, and showing the abrasion resistance of Example 1 and the conventional examples 1 and 2 on it for abrasion loss ($1.02x10^{-11}m^3/N-m$). scratching Example 1 and comparing it with the conventional examples 1 and 2 irrespective of a wear rate in an abrasion region, as shown in drawing 3 -- a ratio -- there is little abrasion loss and it turns out that abrasion resistance is excellent.
[0034]When Example 1 was compared with the conventional example 1, the difference arose in maximum hardness and there was no difference in the toughness near the roll surface. To the conventional example 1, Example 1 adds a proper quantity of Mo of a carbide formation element, and is raising the abrasion resistance after high-frequency induction hardening. Since the conventional example 1 has added V so much, it becomes disadvantageous by a cost aspect.
[0035]Although a difference was not looked at by maximum hardness when Example 1 was compared with the conventional example 2, toughness [/ near the surface of Example 1] was superior to the conventional example 2. To the conventional example 2, Example 1 adds V, forms VC carbide, and is raising abrasion resistance. On the other hand, the conventional example 2 did not add V, but added nickel instead, and has secured the hardenability of a raw material. For this reason, although a difference arises from the surface to ****** and a difference is not observed in the maximum hardness in the surface, a difference arises in the toughness near the surface.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]They are graph charts taking Vickers hardness (HV) along a vertical axis, and taking the depth (mm) from a roll surface along a horizontal axis and in which showing the hardness distribution of the reduction roll of Example 1 and the conventional examples 1 and 2.
[Drawing 2]They are graph charts taking a Charpy impact value (J/cm^2) along a vertical axis and in which showing the toughness of Example 1 in a 30 thru/or 50-mm part, and the conventional examples 1 and 2 towards the central part from a roll surface.
[Drawing 3]a vertical axis -- a ratio -- they are graph charts taking a wear rate (m/second) along a horizontal axis, and showing the abrasion resistance of Example 1 and the conventional examples 1 and 2 on it for abrasion loss ($1.02x10^{-11}m^3/N-m$).

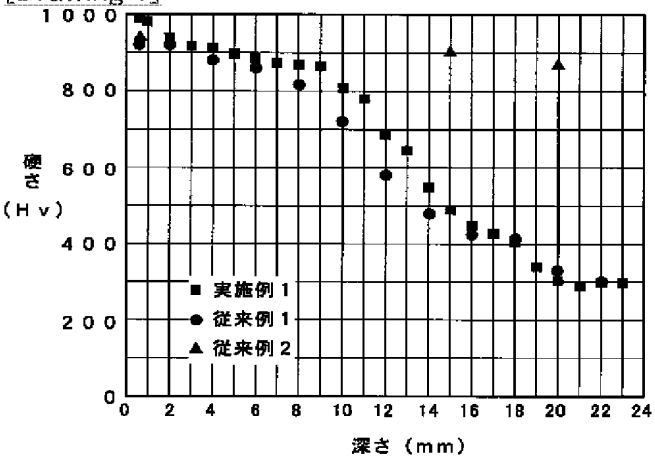
[Translation done.]

* NOTICES *

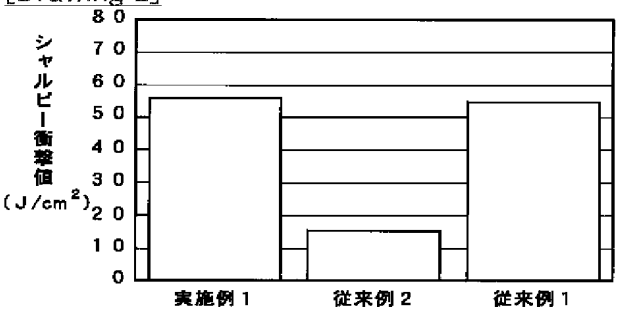
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

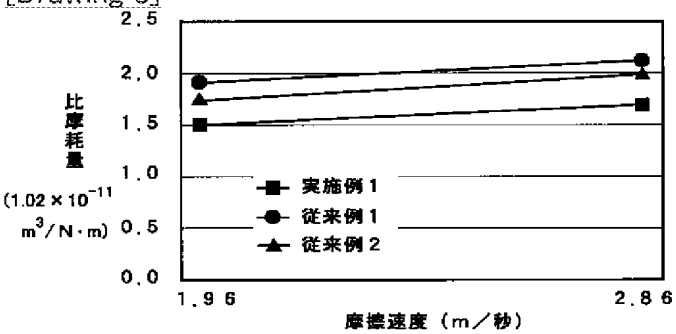
[Drawing 1]



[Drawing 2]



[Drawing 3]



[Translation done.]

WRITTEN AMENDMENT

---------- [Written amendment]
[Filing date]June 20, Heisei 13 (2001.6.20)
[Amendment 1]
[Document to be Amended]Specification
[Item(s) to be Amended]0021
[Method of Amendment]Change
[Proposed Amendment]
[0021]The roll which has the chemical composition of Examples 1-3 of this invention, the above-mentioned conventional example 1, and the conventional example 2 was manufactured as a cold rolling roll. First, the ingot which has the chemical composition shown in the following table 1 was cast, and hot forging, balling-up annealing, and rough machining were performed. Then, hardening temper of the main part was performed and case hardening was carried out on the conditions shown in the following table 2. It is shown that the slash shown in the column of nickel of the following table 1 is an unescapable impurity level.
[Amendment 2]
[Document to be Amended]Specification
[Item(s) to be Amended]0025
[Method of Amendment]Change
[Proposed Amendment]
[0025]The cost which production of the obtained roll takes, the maximum hardness of a roll, the hardness penetration of a roll, the toughness of a roll, and the above-mentioned wear-resistant evaluation are shown in the following table 4. The addition of V and nickel estimated, V addition made O that by which nickel is not added below as for 0.30 mass %, and the cost of the roll made x that by which V addition exceeds 0.30 mass %, or nickel is added. The maximum hardness of the hardness which the maximum hardness of the roll measured made ** O and the thing of less than 940 HV for the thing of 940 or more HV. Hardness [in / in the hardness penetration of a roll / the layer part from a roll surface to 4 thru/or 8 mm] made the thing of 900 or more HV O, and the hardness in the layer part from a roll surface to 4 thru/or 8 mm made the thing of less than 900 HV x.

---------- [Written amendment]
[Filing date]July 17, Heisei 13 (2001.7.17)
[Amendment 1]
[Document to be Amended]Specification
[Item(s) to be Amended]0025
[Method of Amendment]Change
[Proposed Amendment]
[0025]The cost which production of the obtained roll takes, the maximum hardness of a roll, the hardness penetration of a roll, the toughness of a roll, and the above-mentioned wear-resistant evaluation are shown in the following table 4. The addition of V and nickel estimated, V addition made O that by which nickel is not added below as for 0.30 mass %, and the cost of the roll made x that by which V addition exceeds 0.30 mass %, or nickel is added. The maximum hardness of the hardness which the maximum hardness of the roll measured made ** O and the thing of less than 940 HV for the thing of 940 or more HV. The hardness in the layer part

up to 4 thru/or 8 mm the hardness penetration of a roll from a roll surface 900 or more HV, And the hardness in an inside made the thing of less than 900 HV O rather than the layer part, and hardness [in / from the thing and layer part of less than 900 HV / in the hardness in the layer part from a roll surface to 4 thru/or 8 mm / an inside] made the thing of 900 or more HV x.

[Translation done.]